IN THE SPECIFICATION

1. Please amend paragraph [0003], to read as follows:

Jaisinghani, *A Safe Ionizing Field Electronically Enhanced Filter and Process For Safely Ionizing A Field Of An Electrically Enhanced Filter* U.S. Patent No. 5,403,383, describes an ionizing electrically enhanced filter that has sufficiently high performance to have become the only successfully commercialized Electrically Enhanced Filter (*i.e.*, EEF). It has found uses in cleanrooms and in other critical applications, and also in residential and commercial building applications requiring clean indoor air. Recently, *Consumer Reports* (~~Feb. 2002~~ Feb 2003) rated a device based on the teachings of this patent as being the highest performance residential air cleaner.

2. Please amend paragraph [0024], to read as follows:

These and other objects may be achieved with a deep V-pack filter element bearing a charge transfer electrode (*i.e.*, a CTE electrode) formed on the obverse side of the filter media and a ground potential electrode formed on the reverse side of the filter media. The filter element may be disposed within the flow of a stream of transient air directed toward the obverse side of the filter medium bearing the charge transfer electrode oriented toward the upstream side of an electrostatically stimulating filtering apparatus, while an ionizer with a single ionizing electrode,

or in alternative embodiments, a plurality of ionizing electrodes positioned in an array, is spaced-apart from opposite facing charge transfer electrodes. The ionizing electrode is located between ~~and extends parallel to the exposed surfaces of~~ the control ground electrode and the charge transfer electrode~~, with the length of the ionizing electrode oriented perpendicularly to the direction of the flow of transient air~~. A control electrode maintained at a local reference potential, is spaced apart and upstream from the ionizing electrode.

3. Please amend paragraph [0028], to read as follows:

Fig. 3 is a two coordinate graph illustrating the amplitude of voltage induced on the upstream electrodes as a function of distance between the nearest ionizing electrode and the upstream <u>charge transfer</u> electrodes.

4. Please amend paragraph [0035], to read as follows:

Figs. 11A, 11B, 11C and 11D are enlarged, sectional views showing the different patterns of the electrical conductors and perforations within the electrical conductors, in various patterns that might be used as the charge transfer electrode or the downstream ground electrode for the filter element; is an enlarged view showing the printed lines that may be formed to serve <u>as</u> the charge transfer electrode on the filter element.

5. Please amend paragraph [0043], to read as follows:

Fig. 19 is an isometric view illustrating an arrangement of a typical housing for an embodiment of the present invention <u>while Fig. 19A is a side view of an alternative embodiment of a grounding clip</u>; and

6. Please amend paragraph [0047], to read as follows:

Turning now to the drawings collectively, and particularly to Fig. 1a, which shows an elevation view of an inlet side of a filter assembly 31 for an ionizing field electronically enhanced filter 100 with the ionizer assembly removed, Fig. 1b which shows enlarged details of the downstream outlet side of filter assembly 31, and Fig. 1c which shows an elevation view of the downstream outlet side of filter assembly 31. Filter assembly 31 may be constructed with an exterior frame 24, that may be made of sheet metal or any other electrically conductive or non-electrically conductive material, enclosing an array formed by one, or more, deep accordion folds of a pleated filter medium 1 covered, on the upstream, or inlet side, by the pattern of a charge transfer electrode 5. <u>Alternatively, the filter folds 52, may be formed using flat mats or felts with thickness 16, or thin paper sheets 17.</u> In Figs. 1 and 2, the patterns of charge transfer electrodes 5 and downstream ground electrodes 4 are shown to resemble honeycombs in cross-section (as is better seen in Fig. 11); other patterns may be used for charge transfer electrodes 5 and downstream ground electrodes 4; the honeycombed pattern illustrated is only one of many perforated patterns

that may be used for electrodes 4, 5 to cover the downstream and upstream exposed surfaces of filter material 1, 16 or 17. Note that in Fig. 1 only the lower portion of filter assembly 3 on the upstream side is visible. It should be noted that both the upper and the lower side of upstream surface portions of the filter assembly ~~3~~ 31 of each pair of arms ~~54~~ 52 forming each pocket of filter medium 1, 16 or 17 into a V-shaped ~~pleat~~ fold 52 ~~of the composite filter medium 16~~ has the transfer electrode 5 applied to it. ~~Filter medium 1~~ Arms of the folds 52 may also be constructed with all of the several folds ~~all forming~~ formed from the same part of the ~~same~~ continuous layer of material 1, 16, or 17 ~~such as felt or alternatively, a mat~~.

7. Please amend paragraph [0048], to read as follows:

Alternatively, end caps 2a, 2 encapsulate filter medium 1, 16, or 17 and possibly one or more electrodes 4, 5 extend horizontally across the inlet and outlet sides, respectively, between side frames 24. End caps 2a ~~restrict~~ force the entrance of particulate bearing air, indicated by arrows "A", ~~to the interstices remaining between each of the end caps 2a, thereby forcing the air~~ into ~~one of~~ the V-shaped pleat packs 52 only. Pleat packs 52 may be joined at an apex 50. End caps 2 on the outlet side also restricts passage of the air to the V-shaped pleat packs 52. Consequently, particulate laden air drawn or pushed into the inlet side of filter 31, passes through the broad planar areas provided by the several ~~pleats~~ folds of filter medium 1, 16 or 17.

8. Please amend paragraph [0049], to read as follows:

Charge transfer electrodes 5 may be formed on the exposed outer, or upstream, surfaces of the V-shaped ~~pleat packs~~ folds 52 on the inlet side of medium 1, 16 or 17, while downstream ground electrodes 4 may be formed on the exposed, opposite outer, or downstream, surfaces of the V-shaped ~~pleat packs~~ folds 52 on the outlet side as illustrated by Figs. 1b, 1c. Electrodes 4, 5 may describe honeycomb grid patterns as shown in Figs. 1a-1c, or any of various screen or grid patterns that cover the opposite exposed parallel sides of medium 1, 16 or 17, to each form a discrete, continuous electrode 4, 5 that may be maintained at a single, constant and uniform potential. Alternatively, when end caps 2 and 2a are used, electrodes 4, 5 may be formed by inserting flat or V shaped perforated metal plates within the ~~pleat packs~~ V forming folds 52. The induced voltage on the electrodes 5 is then dependent on the smallest value of d_2 achieved. Thus an advantage of uniform charge transfer potential across the filter medium is achieved. ~~In that case the~~ The downstream ground electrodes 4 are then maintained at ground potential by use of a grounded clip or clips or other mechanical means. Electrodes 4 and 5 are electronically isolated from one another so that they may be maintained at different electrical potentials during operation of filter 100, and are physically separated by the thickness d_3 of the ~~filter~~ medium ~~1,~~ 16 or 17 of filter 1.

9. Please amend paragraph [0051], to read as follows:

Referring now to Figs. 2 and 3, I have found that with embedded upstream corrugated

spacers, which are inherently electrically isolated from one another, variations occurring in the induced field depends on the distance d_2 between electrodes 8 and the upstream corrugated spacers at a fixed applied potential to electrodes 8. When both the tolerances in media folds and aluminum spacers are taken into account, this can mean large variations in induced potentials and hence in collection field strength and therefore in filtration performance within various sections of the filter medium.

Typically, the folded glass fiber media used in filters with aluminum separators in structures such as taught by Cheney '736, is about 0.02" thick. I have found that it is very difficult, if not impossible, to achieve identical folds that is, folds with less than 0.08" variation in ~~thickness~~ fold length and identical corrugated separators, that is, tolerances of corrugation angles and cut lengths that are respectively better than five degrees and lengths better than 0.06". Recognizing that ~~in~~ the induced electrical field depends on the least distance d_2 from the ionizing electrode to the upstream corrugated spacers at a fixed applied potential to the wires, when both the tolerances in media folds and aluminum spacers are taken into account, there are concomitantly large and undesirable variations in induced potentials and hence in collection field strength, and therefore erratic filtration performance within various sections of the filter medium. Moreover, the variation in the upstream corrugated spacers alignment with respect to the downstream spacers is responsible for a lack of uniform performance of the filter; the performance will vary from media section to section since the collection field strength will be inversely proportional to the local distance d_3 between the upstream and the downstream electrodes. This means that some sections of the filter will have very low enhancement of filtration efficiency. If deeper pleated spacers are

used, this lack of uniformity and the irregularity and variation are worsened.

10. Please amend paragraph [0052], to read as follows:

A high potential for sparking with contemporary filtering devices such as those of Cheney and Spurgin disclosed in their U.S. Patent No. 4,781,736 occurs because the voltage induced on the upstream electrodes is a function of distance between the upstream electrode and the ionizing electrode. Keeping in mind that, in order to assure the prevention of sparking in such thin media, a voltage higher than about 0.35 kilovolts can not be induced on the upstream electrodes <u>when peaks of the upstream and downstream corrugations are aligned, as shown in Figure 2.</u>~~, referring~~ <u>Referring</u> to Figure 3, one can clearly see how daunting the task of maintaining such a precise gap between each and every one of the upstream electrodes and the inducing wire. Since the aluminum separator electrodes are simply (and thus erratically) placed, unsecured, between the media folds, it is highly likely that some of the electrodes will be too close and cause a higher surface potential on those upstream corrugated electrodes that are closer to the high voltage wire, resulting in corona discharge and sparking at points where the peaks of the upstream and downstream corrugations of the electrodes align. Sparking may burn holes in the filter media and has the potential to cause a fire if the sparking is continuous. In tests that I have done, it was practically impossible to get a filter element that had been constructed with aluminum separators to function without sparking while simultaneously achieving a significant improvement in filtration, especially under higher humidity (*i.e.*, 60% or higher) conditions. Even if an ideal manufacturing method was developed

for making filters with aluminum separators separating neighboring layers of the filter medium, contemporary practice has been unable to predictably control the distance between corrugated electrodes and the high voltage wire so that no sparking occurred and, at the same time, filtration performance was significantly improved. Moreover, contemporary practice with aluminum separators still results in significant variations <u>in</u> the alignment of the upstream and downstream separator peaks and valleys and thus the distance d_3 between the adjacent upstream and downstream electrode surfaces and, therefore, the strength of collection fields across different portions of the filter.

11. Please amend paragraph [0054], to read as follows:

Now consider the variation in the alignment of the peaks and valleys of the upstream corrugated spacers with respect to the adjacent downstream spacers. Fig. 2 shows two of the many variations in alignment that are possible. In one case the alignment of the peaks are off by approximately 45 degrees. This results in Min1 and Max1 distances d_3, between the upstream and the downstream spacers. In this case the performance will vary from media section to section since the collection field strength will be inversely proportional to d_3 (collection field strength = Vinduced / d_3). Now consider the case (which must be considered because this will occur often within the filter media folds) when the spacers are mis-aligned by about 180 degrees - *i.e.,* peaks will coincide or almost coincide as shown in bottom section of Fig. 2. In this case of Min2, d_3 is equal to the media thickness and at Max2, d_3 is equal to twice the depth of the spacers. The

maximum induced voltage on the upstream corrugated spacer electrode in their device can only be about 0.35 kilo-Volts in order to safely eliminate sparking through the media (thereby preventing damage to the media and avoiding a fire) towards the opposite corrugated electrode spacer (which is also within the pleat) at ground potential on the other side of the pleat at the point where the peaks are aligned as in Min2 d_3. This corresponds to a collection field strength of about 17 kilo-Volts/inch, but only when the peaks of the upstream corrugated electrode are facing (see Fig. 2) the corrugated counter spacer electrode peaks (as in Min2 [[d3]] $\underline{d}_3$) on the opposite side of the media. A collection field strength of about 12-15 kilo-Volts/inch, is desirable for effective collection of particles on the filter media. Consider now that for the Max2 d_3 section of the media, the collection field strength at that section will be 0.35 kilo-Volts/0.52" = 0.67 kilo-Volts/inch, if 0.25" separator corrugations (which are the smallest size corrugations ~~that are available~~) are used. This collection field strength 0.67 kilo-Volts/inch is negligible for efficient filtration of particles from the air stream. It will not be possible to induce an adequately higher voltage on the upstream corrugated electrode to compensate for this, because then the field strength at the Min2 d3 section will exceed the safe no sparking or arcing limit. This means that this section <u>(Max2 d3)</u> of the filter will have very low enhancement of filtration efficiency. If deeper pleated spacers are used, this situation is worsened. Of course, it should be noted that all sorts of situations in between these two situations can exist. Essentially, this results in a non-uniform <u>and low overall</u> performance. Keeping in mind that filters are mostly rated by their weakest performing section, this structural configuration will not result in high enough filtration enhancement.

12. Please amend paragraph [0056], to read as follows:

Since the filter medium used in embedded electrically conducting separators are highly porous (*e.g.*, porosity > 90-95%) and the minimum distance.~~, d_2 Low,~~These definitions have nothing to do with the downstream ground between the high voltage wire and the downstream corrugated electrode is not significantly greater than the distance, ~~d_2 High,~~ between the wire and the upstream corrugated electrode, there will be a considerable amount of leakage current towards the downstream corrugated electrode which is maintained at ground potential. Any leakage current will make the device inefficient. This situation is worsened when the glass filter paper absorbs moisture as a result of high humidity.

13. Please amend paragraph [0057], to read as follows:

In order to prevent sparking towards the frame material, the frame material in the practice of Cheney '736 must be non-conductive because the aluminum spacers of the upstream corrugated electrodes will have a high probability of contacting the frame material. Typically, wood or particle board products are used. Most current manufacturing methods have switched to the use of aluminum or metal channel frames since these are non-particle shedding, result in better seals to the media, and are not flammable. Cheney '736's wood is a ~~rather~~ relatively dirty material and thus ~~unsuitable~~ less suitable for cleanroom applications.

14. Please amend paragraph [0059], to read as follows:

Figs. 4 and 5 schematically illustrate several features implementing the principles of the present invention as two possible configurations of an ionizing, electrically enhanced filter modified according to the principles of the present invention with generally non-conductive filter media. A perforated, electrically conducting charge transfer electrode 5 formed as a continuous grid, is placed upon and borne by the upstream surface of filter medium 1; electrode 5 is electrically isolated from direct conduction with a local reference potential such as ground, and from any counter potential electrodes 4, 7 (which may be maintained at a reference, or ground, potential) <u>and from the ionizing electrode 8</u>. I have found that tests show that the surface potential achieved on charge transfer electrode 5 with the embodiment shown in Fig. 4 is the same as the surface potential on the peaks of the filter medium in the absence of electrically conductive, perforated electrode 5, which is the same result obtained in Jaisinghani U.S. Patent No. 5,403,383. The results are summarized below in Table I:

<Table I>

15. Please amend paragraph [0061], to read as follows:

Turning now to Fig. 5, if filter element 1 and charge transfer electrode 5 are both tilted at an oblique angle relative to ground control electrode 7 and the <u>nominal</u> direction of impinging airflow indicated by arrow A, and another filter medium pack ~~54~~ <u>52</u> is added to form a V-shape,

then the embodiment of this invention shown by Figs. 6 and 8 results. In this embodiment, the distance between ionizing electrodes 8 and the control electrode 7, d_1, primarily determines the particle charging field strength, that is, the corona generation, which results in ion formation and charging of incoming particles carried by air entering filter 1 in the direction of arrow A.

16. Please amend paragraph [0063], to read as follows:

The mechanism involved is not simple electrical induction. Referring to Table II and Fig. 16, the charge is transferred well into the exponential or corona generation portion of the curve. Unlike the Cheney and Spurgin, the resulting potential on CTE 5 is at least an order of magnitude (actually two orders of magnitude in the example shown in Table II) higher than the estimated potential that could safely be induced on the separators of the Cheney and Spurgin reference. The charge is eventually transferred across the filter to the downstream ground electrodes via the small, but finite conductivity of the generally non-conductive and dielectric filter medium. There is a net equilibrium charge accumulated however, and this results in a high surface potential, with a magnitude that is in between that of the voltage applied to the ionizing electrodes and the potential of the downstream ground electrodes, that are typically at ground potential. CTE 5 may be made of a conductive material such as aluminum or other metal, so that the potential is constant across the entire face of CTE 5. Thus the <u>minimum</u> distance, d_2, controls the value of the CTE potential for any given applied potential on the charging corona wires. Since the downstream ground electrodes and the CTE 5 are essentially parallel because they run along the planes of the filter

media, the collection field strength (V_{CTE} / d_3) is high enough when compared to that of the flat configurations of contemporary design and also stable and constant across the filter medium, and without risk of spark discharge across filter medium 1.

17. Please amend paragraph [0065], to read as follows:

Fig. 6 illustrates a deep V-pack arrangement of filter medium [[1]] arranged in a pleated configuration. This electrode configuration enables use of deep filter [[1]] in a safe, efficient and risk free manner - something that is not possible with contemporary designs. In this V-pack arrangement, the layer of filter paper ~~medium 1~~ may be ~~repeated~~ repeatedly folded to form a pleated filter medium 1 ~~16~~ which exhibits numerous folds or pleats and undulates alternately between the plane of downstream electrode 4 and upstream electrode 5. The extreme ratio between the length of each pleat of medium 1 within the V-pack to the fineness of the pitch between successive pleats enables the V-pack to contain much more filter media while providing a lower pressure drop along the path of the transient air flow. Filter medium 1 is itself not deep, but is configured into a V-pack arrangement that is quite deep. Typically, the pleat length or pleat depth used is between 0.5" - 2" in such V-packs though other pleat depths may also be successfully used within the ~~scop~~ scope of this invention.

18. Please amend paragraph [0066], to read as follows:

Referring collectively to Figs. 6 and 10, a ~~A~~ set of CTEs 5 are located on the upstream face of filter medium 1 and spaced apart from the ionizer wires 8 by a distance d_2. The charge transfer electrodes 5 should have no electrical contact with any other electrically conducting member. If the upstream end caps 2a that hold the V-packs in place are metal, then a gap 6, of about 0.25" to 0.5" (depending on the applied high voltage) is maintained between the end caps 2a and charge transfer electrode 5. If the end caps 2a are made from non-conductive or dielectric material however, then there is no need for such a gap 6. On the downstream side, a set of perforated downstream ground electrodes (DGE) 4, are applied to filter medium 1. In this case it is actually preferred that the downstream end caps 2 be made of metal and that the downstream ground electrodes be in direct electrical contact with metal end caps 2. An electrical charge is transferred to CTEs 5 by ionizer assembly 30. Ionizer assembly 30 is a frame that is positioned so as to hold ionizing electrodes 8 preferably (though not necessarily) parallel to and spaced apart by a constant, fixed minimum distance d_2 from the CTE 5.

19. Please amend paragraph [0067], to read as follows:

Referring again to Fig. 6, the gap d_2 between high voltage ionizing electrodes 8, and CTE 5, is such that the field strength across the filter medium 1, (defined as CTE potential divided by the distance d_3 between CTE 5 and the downstream ground electrode (DGE) 4), is essentially the

same as the field strength across ~~filter~~ medium 16 of the flat configuration as described in Jaisinghani '383. Additionally, the gap d_1 between the high voltage ionizing electrodes 8, and the control electrode 7, is such that charging of airborne particles within transient air is achieved - *i.e.*, the charging field strength (defined as the potential applied to electrodes 8 divided by d_1) is similar to the field strength used in Jaisinghani U.S. Patent No. 5,403,383.

20. Please amend paragraph [0073], to read as follows:

Two other configurations are shown by Figs. 8 and 9. In Fig. 8 CTE 5 is held against the upstream face of relatively thick (typically exhibiting thicknesses from 0.125-2"), non-pleated filter medium 16. This is one distinction between the embodiment illustrated by Fig. 8 and the configuration of Fig. 6. It is important to note that in these configurations CTE 5 is made of flat metal plates perforated by numerous interstices 160 accommodating passage of transient air, with every part of CTE 5 positioned essentially in direct physical contract with the upstream outer exposed, major surface of filter medium <u>1 or</u> 16; CTE 5 does not function as a spacer and hence need not be in corrugated form as the aluminum spacers used in the contemporary designs represented by Cheney *et al.* U.S. Patent No. 4,781,736. As discussed previously, with spacers that are corrugated, the field strength across the filter medium is non-uniform and can result in sparking and the burning of holes in and through the filter medium.

21. Please amend paragraph [0076], to read as follows:

Fig. 9 shows the configuration using non-pleated, folded, thin paper medium 17. When filter medium 17 is in a very thin paper form, even when in the non-corrugated spacer electrode configuration shown, it can become extremely difficult to assure that no sparking or electrical discharge occurs anywhere across the structure of medium 17. In that case, a small air gap between CTE 5 and filter medium 17 may be maintained so as to enable stable and safe operation. Alternatively, the air gap ~~spacers~~ may be applied to ~~thte~~ the DGE 4 instead of CTE 5 to create the same effect. The gap may be maintained with spacers 18 made of a relatively higher electrical resistance glue beads, although other higher resistance polymeric spacers may also be used. It should be noted that the spacers are not separating the folds of the filter medium 17, but are spacing apart electrodes 5 or 4 from the filter medium 17. The addition of the gap enables the device to operate at a higher and more stable potential difference between CTE5 and ionizing electrodes 8. Effectively, the distance d_3 is increased by the non-electrically conducting, insulators 18 serving as spacers between CTE 5 and the upstream outer surface of medium 17, and this larger distance d_3 is compensated for by applying a higher, and more stable CTE potential which is controlled by distance d_2 and the ionizing field strength V_{app}/d_1. This assures proper and stable collection field strength for operation without arcing. ~~CTE electrodes 5 must be shorter than the folds in filter medium 17 by approximately, 0.25" to 0.1", depending on the design CTE voltage. Alternatively, the~~ The CTE may wrap around the filter medium 17 provided however that a minimum gap of 0.1-0.25" is maintained between the CTE 5 and the ground control electrode 7.

Alternatively, the electrodes 5 may be shorter than the folds of the filter medium 17 by approximately 0.1 to 0.25" at the end closest to the ionizing electrodes 8. This gap depends upon the design value of the CTE 5 potential and the thickness of the filter medium.

22. Please amend paragraph [0077], to read as follows:

Turning now to Figs. 10 and 11A, 11B, 11C and 11D, either or both the downstream ground electrode 4 and the CTE 5 may be deposited as an electrically conductive pattern of electrical conductors 150 that form a grid that is perforated by numerous interstices which accommodate a flow of air or other gaseous influent through CTE 5 and ~~filter~~ the material ~~1,~~ 16, 17 of filter medium 1. Conductors 150 may be printed directly onto either or both the upstream and downstream outer surface of filter medium 1, 16 or 17 in a grid such as a honeycomb pattern shown by Fig. 11C, by using a conductive ink or paint with appropriate openings to simulate a perforated electrode. Conventional photolithographic or stamping techniques may be used to create such a pattern on either or both the downstream and the upstream surface of filter medium 1, 16 or 17. In this case there is no necessity of using metal plates for CTE 5 and DGE 4, although plates of an electrically conductive material could also be used if the pleated configuration was used with CTE 5 deposited on the upstream surface of filter medium 16 or 17 and if the conductivity of the printed CTE 5 was not high or had an intermediate level. In that case, the printing will enable a higher collection field strength without the application of a higher amplitude of V_{CTE} or without reducing the value of d_2 to an untenably low value. All other aspects of this

embodiment may be constructed similarly to those illustrated by Figs 6, 8 and 9. If end caps 2a are made from a non-electrically conducting material such as plastic, no gap 6 is necessary. If end caps 2a ~~6~~ are made from an electrically conducting material, the width of gap 6 is dependent upon the charge held by CTE 5.

23. Please amend paragraph [0078], to read as follows:

A dual filter layer configuration is illustrated by Fig. 12 and may be constructed according to the principles of the present invention, with an electrically conductive fibrous layer 19 which serves as a pre-filter, an electrically conductive or relatively conductive, pre filter layer 19 or a porous paper layer 19 may be used, instead of the electrically conductive metal CTE 5, on the upstream exterior surface of the non-electrically conductive filter medium 17. This conductive fiber configuration can also function as a pre-filtration device. Although Figs 12 only shows a dual media 19, 17 with the flat filter medium 17 configuration, it should be noted that this method can also be applied to the pleated configuration of medium ~~16~~ 1 illustrated by Fig. 6. It should be noted that when using dual media 19, 17 configuration, it is important that a small gap 6 of between approximately 0.1 to about 1.0 inches be maintained between ground control electrode 7 and conductive medium 19 which functions as the CTE charge transfer electrode.

24. Please amend paragraph [0079], to read as follows:

Turning now to Fig. 13, resistive control of transfer electrode 5 may be established in order to limit the CTE 5 potential other than the local reference, or ground potential. Instead of letting CTE 5 float or be totally electrically isolated, CTE 5 may be connected to a local reference potential such as a ground or to the opposite downstream ground electrode 4 via a high resistance resistor R_{20} in the mega-ohm range. Resistor R_{20} is coupled in parallel to the much higher resistance of ~~filter~~ the medium ~~1,~~ 16, 17 of filter 1. This will limit the accumulated charge on CTE 5, resulting in a lower or limiting potential at CTE 5. ~~Thus,~~This technique may be used to control the CTE potential in addition to varying the distance d_2. This technique may be useful when d_2 is small and slight and precise variations of d_2 are not practical. The use of resistor R_{20} provides a secondary way of controlling the collection field strength and also ensuring the safety of filter device 1 by inhibiting arcing. Fig. 13 shows resistor R_{20} applied to the configuration detailed in Fig. 6. This technique may be used in one or more of the several possible combinations with the other basic configurations described here using either flat or deeply pleated V-packs.

25. Please amend paragraph [0081], to read as follows:

Referring now to Figs. 1, 6, 15, 17, 18 and 19 collectively, the configurations described in the foregoing paragraphs may be put into practice with either deep V-pack pleated filters made with glue beads, ribbon separators or a separatorless mini-pleated filter medium 1 ~~16~~ illustrated

in Fig. 6, or with an unpleated, continuously flat filter medium 16, 17, regardless of whether the filter medium is constructed with thick felt of fiber mat 16 or with a thinner layer made of a porous material such as paper 17, as is shown by Figs 8 and 9.

26. Please amend paragraph [0084], to read as follows:

End caps 2 shown by Fig. 1b on the downstream side of the filter are preferably made of an electrically conductive metal, which is in electrical continuity with the metal framing material or channel that encompasses the filter as a housing. The downstream ground electrode plates 4 are inserted within end caps 2 in electrical contact to provide electrical continuity with end caps 2 which are maintained in electrical continuity with the conductive frame of the filter. Thus, only one point on the frame of the filter needs to be grounded or set to a opposing potential in order that all of the downstream ground electrodes plates 4 will be at the same potential. This grounding may be typically accomplished by a metal grounding clip 47, which contacts the filter end caps as the filter is tightened against the seal plate 34 as shown by Fig. 19. Different mechanical devices that enable ground contact may also be used in lieu of grounding clip 47. If the filter frame or end cap 2 is made of non-conductive material or if contact of the downstream ground electrode 4 with the end caps 2 or contact between end caps 2 and filter frame is not feasible, then instead U-shaped grounded metal or conductive clips may be used to make frictional contact with each of the ground electrodes 4 at the apex of the V-packs. Thus each U shaped clip can provide ground contact for two of the ground electrodes (which cover 4 surfaces of the filter packs) if the ground electrodes

4 are in a V shape *i.e.,* they are continuous between two adjacent surfaces of the V-pack filter.

27. Please amend paragraph [0086], to read as follows:

The non-pleated filter medium 16, 17 may be incorporated into a non-pleated configuration suitable for use in lower efficiency filtration applications, although non-pleated filter media may be adapted to higher filtration applications also. The filter medium may be in a flat, continuous thick mat or felt form 16 as shown in Fig. 8, or in thin paper form 17 as shown in Fig. 9.

28. Please amend paragraph [0087], to read as follows:

Fig. 17A shows one embodiment of the filter assembly 3 with filter medium 16, 17 bonded into the preferably non-electrically conductive frame of filter assembly 24 to form a potted filter element 186 via a plastisol or other adhesive as in the case of the V-pack filter described above, with filter medium 16, 17 maintained in direct contact via light bonding by means of an adhesive to downstream ground electrodes 4 which is in an electrically conductive, continuous, deeply pleated or corrugated and perforated form. CTE 5 may similarly be a continuous deeply pleated or corrugated and perforated, electrically conductive member that is then attached to the frame 24 such that it is in essential contact with the filter medium, or if the filter medium is very thin paper, depending on the electrical design, a small gap 18 of about 0.04" to 0.25" may be maintained between CTE 5 and the upstream surface of filter medium 17 in order to achieve charge stability

without risk of spark discharge. Glue beads 18 may be used on the CTE 5 to also ensure this separation distance between medium 17 and CTE 5. This embodiment is a throw-away filter and is deployed for high filtration efficiency applications. Downstream ground electrode 4 which is also a continuously deeply pleated or corrugated and perforated, electrically conductive member, is removable and is designed to fit into the pleated form of CTE 5 , which is constructed as a discrete member, such that there is enough room for filter medium 17 in between CTE 5 and electrode 4 when the downstream ground electrode 4 is attached to the frame via a set of screws 41 or other fasteners such as clips.

29. Please amend paragraph [0088], to read as follows:

Fig. 17B shows the non-pleated media 16, 17 embodiment 188 which enables a user to simply replace the filter media when it gets dirty with ~~entraped~~ entrapped particles, rather than throwing away the entire filter assembly. Consequently this embodiment is usually not deployed for high filtration efficiency where high filtration efficiency is defined as applications for filtration providing greater than approximately 95% particle removal at sub-micron particle sizes. Non-conductive frame 24 which may be part of a filter housing or may be a separate component within such a housing, is used. CTE 5 is attached to this frame and is in a continuous deeply pleated or corrugated and perforated conductive form. Downstream ground electrode 4 which is also a continuously pleated and perforated, electrically conductive member, is removable and is designed to fit into the pleated form of CTE 5 , which is constructed as a discrete member, such that there

is enough room for filter medium 17 in between CTE 5 and electrode 4 when the downstream ground electrode 4 is attached to the frame via a set of screws 41 or other fasteners such as clips. Downstream ground electrode 4 has a flanged edge 39 which is sealed along with the filter medium against the edge flange of filter frame 24. The other perpendicular edges of the filter medium 16, 17 are relatively sealed to the frame by a layer of fiberglass or mat 40 or another material, that is able to prevent the passage of dust, that is glued to the top inner and bottom surfaces of filter frame 24. Alternatively, the system can be designed such that CTE 5 is removable and the downstream ground electrode 4 is fixed into the filter frame. Alternatively both the CTE 5 and ground electrode 4 may be removable. Other techniques may also be used to enable filter media replacement in the practice of this invention.

30. Please amend paragraph [0089], to read as follows:

If a very thin filter medium 17 is to be used, then CTE 5 and downstream ground electrode 4 may be fitted with fastening points to the frame 24 so that there is there is space between the CTE 5 and electrode 4 for the media plus about 0.04"-0.25", depending on the design of CTE 5 and the voltage applied to CTE 5. Typically the filter medium used is attached to the downstream ground electrode 4 or the CTE 5 member by means of either Velcro® strips attached to various points on the electrodes and on corresponding points on the filter medium or is simply pushed and maintained against the ground electrode 4 by the CTE 5 (or vice versa) or the members for creating the space described above, attached on the CTE 5. For improved contact to ground the filter

medium 17 may have portions of it covered with conductive paint either by printing a pattern on it (similar to the printed CTE 5) or just along the edges of the folds. This conductive coating can assure better ground contact on the downstream side of the filter medium 17. Filter medium 17 is usually manufactured with folds or creases, which coincide with the pleats or corrugations or folds of downstream ground electrode 4 to facilitate attachment of the filter medium to downstream ground electrode 4 or CTE 5. To replace filter medium 17, the downstream ground electrodes 4 or CTE 5 is detached from the frame 24 and the dirty filter medium is replaced with a clean new folded medium.

31. Please amend paragraph [0091], to read as follows:

The ionizer assembly 30 shown in the enlarged view in Fig. [[6]] 7 is constructed with a perforated metal plate 7, with or without the pre-filter channel 25 or other mechanism used to hold a prefilter 45 at the upstream face of the ionizer. Onto this plate 7 high voltage electrodes 8, typically made of Tungsten are mounted at a separation of distance d_1 from the perforated metal plate. Electrodes 8 are mounted as single wires or in pairs or sets of wires, spaced between about 0.75" to 2" ~~and about 20"~~ apart, depending on the opening within each of the V-packs or flat filter folds, onto a bus bar 10 which is in turn is mounted on top of dielectric and non-electrically conductive standoff or standoffs 13 made of non-electrically conducting material such as a ceramic. Stand-offs 13 typically are threaded on the inside at both ends so as to enable mounting via screws 12 on to a small non perforated section of the generally perforated metal plate (control

ground electrode) 7 on one end, and the conductive metal bus bar 10 on the other end of each standoff 13. Wire electrodes ~~Electrodes~~ 8 are then attached typically via springs 9 to holes 15 by using loops on the spring, to bus bars 10 and extended towards a similar opposing bus bar and spring assembly across the control ground electrode 7, so that the wires can be installed typically within the V opening. Alternately the bus bar may have one or more needle or sharp points on it to serve as ionization points. High voltage is applied to bus bar 10 and thence to electrodes 8 via high voltage cable 11 which is typically connected to a high DC voltage power supply via quick connect high voltage couplers. In order to eliminate any potential arcing from any rough metal surface of the ionizer's 30 bus bar 10, springs 9 or wire or spring loops, a dielectric non-electrically conductive C-shaped, channel shield 14 may be used to shield these components from other surfaces as shown in the enlargement of Fig. 6 presented by Fig. 7. Alternatively, instead of a C-channel, a flat dielectric plate covering the top of the entirety bus bar 10 and spring assembly may be used. Typically, non-electrically conducting materials such as acrylic or appropriate nylon or polycarbonate, which have appropriate dielectric properties, may be used to form shield 14.

32. Please amend paragraph [0092], to read as follows:

Referring now to Fig. 15 and Fig. 19, ionizer assembly 30 may be attached to filter assembly 31 using fasteners such as threaded bolts or screws 23 which fit into metal guide tabs 21 attached to the exterior of filter housing 24. A wing nut 22 or other removably receptive fastener may be used to secure bolts 23. Tabs 21 enable one or sets or pairs of ionizer electrodes 8 to be

correctly spaced within each V-shaped pair of pleats of filter assembly 31, while maintaining correct values of d_2 (cf Table II). The maintenance of proper values of d_2 for each of ionizing electrodes 8 and charge transfer electrodes 5 is important to assure the safe and efficient operation of the deep electrically enhanced filter. Alternatively, the ionizer assembly 30 may be constructed with angle guides so that it can be pushed against ~~the~~ filter assembly 31 only in one way so as to maintain the above gap d_2 between the wires 8 and the CTE 5. The ionizer assembly 30 and the filter 31 are held and maintained in this position by means of bolts or other means that push both assemblies against the seal plate 34, such that the gasket 26 on ~~the~~ filter assembly 31 is compressed against the seal plate 34.

33. Please amend paragraph [0093], to read as follows:

Fig. 18 shows a housing that can be used to mount single or multiples of such filters and ionizers in air handling units 38. A filter frame assembly 32, which is sealed against a seal plate 34 in air handling unit 38 either by welding or other means such as by using polymeric seal materials. Frame assembly 32 has at least four members 29 mounted on ~~each of the four~~ at least 2 opposite sides; members 29 are installed into brackets with holes onto which a L-shaped rods or members 29 with threaded bolt on the end are inserted. At the threaded end is a L-shaped washer with a nut that threads on to the L-shaped rod. This and other such filter sealing assemblies are available from companies such as Camfil-Farr and AirGaurd among many others, and hence this mechanism need not be drawn in detail or described further here.

34. Please amend paragraph [0095], to read as follows:

In the assembly shown by Fig. 18, it is not possible to use metal guide tabs 21, as shown in Fig. 15, because there is typically no room for guide tabs 21 on the side of filter frame assembly 32. In this case, ionizer assembly 30 is accurately guided into filter assembly 31 by a set of two or four channel guide members 33 attached to the ionizer assembly 31. ~~Ionizer assembly 30 rests snugly inside the space created by guide members 33.~~ Guides 33 fit snugly over the filter assembly thus properly positioning the ionizer assembly 30 within the filter assembly 31. Sealing member 29 then holds assemblies 30 and 31 together.

35. Please amend paragraph [0097], to read as follows:

Fig. 19 shows an isometric view of a typical housing 44 that is separate from the air handling housing 38, that can be used within a duct system that is connected to air handling unit housing 38. The typical housing 44, often referred to as an in-duct filter housing, uses of an optional fan 35 to draw the air through the enhanced filter system, electrical component compartment 37, seal plate 34 and service door 36. The controls and indicators 46, are mounted on the outer surface of electrical compartment 37. A grounding clip 47 of an electrically conducting material such as metal, or with the alternative self-fastening structure of clip 47' bearing deformable retainers 47a shown in Fig. 19A, forms an electrical path of conduction between downstream ground electrode [[5]] 4 via end cap 2, and the electrically conducting frame

of filter assembly 31. The frame of filter assembly 31 serves as a local reference potential such as ground, and may be electrically coupled to a ground potential, such as earth, with a grounding strap (not shown). Optionally if the filter frame is non-conductive a separate ground clip, typically with multiple U members that straddle each apex of the V-pack to make ground contact with each set of ground electrodes 4, may be used. In this case the ground clip is designed to fit on to the filter V-pack apexes in a manner that it also makes contact with the filter housing. Ionizer 30 and filter 31 assemblies are also shown without detail. Either filter assembly 31a or 31b, or another filter assembly, may be used as filter assembly 31. It should be noted that the ionizer control electrode 7 may be formed in a manner such that two U-shaped channels are formed which enable a prefilter to slide into the U-shaped channels. This serves as a convenient prefilter holding assembly. This simple configuration is not shown in detail here. Alternatively, a conventional prefilter frame that attaches to a conventional filter frame may be used as described above for the case of the air handling unit application. If fan 35 is not required in the construction of a particular embodiment, a flow switch or contact provided form an air handler fan may be used so that when there is no airflow, then the high voltage power supply to the ionizer wires is shut down. Service door 36 is positioned so that when door 36 is open, a safety disconnect switch is opened so that all power to the filter unit is disconnected.

36. Please amend paragraph [0098], to read as follows:

Either the upstream side <u>or</u> ~~of~~ the downstream side of the filter depending on which side

the filter is sealed against seal plate 34, has a polymeric (typically closed cell polyurethane foam or rubber) gasket 26 with sufficient hardness for sealing assembly 31 against seal plate 34. Filter assembly 31 is then sealed against seal plate 34 by either applying external force against ionizer assembly 30 by incorporating a bracket 48, which is threaded to move a bolt 49 with knob attached as is shown by Fig. 19, or by tightening nuts or wing nuts 22 onto bolts that are attached to the seal plate. Alternately, the bolts may be moved through nuts mounted on the intake side of the filter housing (around the fan) so as to move against the ionizer-filter assembly. These bolts can also go through the metal guide tabs 21 that are welded on to filter assembly 30. Alternatively, placement of sealing member 29 onto filter frame 32, enables attachment of springs that pull filter assembly 31 onto the seal plate as shown by Fig. 18. Only the bolt 49 sealing configuration is shown in Fig. 19. Filter assembly 31 can also be sealed against seal plate 34 by a variety of other common and conventional sealing mechanisms, such as adding a knife edge to filter assembly 31 or seal plate 34, which seals up against a gel embedded all around seal plate 34 or filter assembly 31. The sealing mechanism is not shown in detail in Fig. 19.

37. Please amend paragraph [0100], to read as follows:

Fig. 21 illustrates the construction of an alternative embodiment with potentially intersecting arms 54 ~~folds 52~~ joined at a curve, or C-shaped apex 50. Ionizing assembly 30 may be constructed with multiples of either a single or a pair depending on the opening of the filter folds, of ionizing electrodes 8, each separated by a least distance d_2 from the closest surface of

CTE 5.

38. Please amend paragraph [0108], to read as follows:

A typical <u>conventional</u> V-pack filter with this <u>pleated V pack</u> construction could exhibit a filter efficiency of 99.99% with a particle size of 0.3 micrometers, and provide a pressure drop of about one inch water column at a filter face flow velocity of 600 feet per minute. Another <u>conventional</u> grade of a V-pack filter with a filtration efficiency of 95% at 0.3 micrometers particle size, and has a pressure drop of about one-half of an inch water column (*i.e.*, 0.5" WC) at a filter face air flow velocity of 600 feet per minute. I have found that if such a 95% filter could be enhanced in a safe electrical manner to provide approximately 99.97 to 99.99% filtration efficiency at 0.3 micrometer particle size (commonly referred to as HEPA filtration efficiency), then an ultra low pressure drop HEPA filter could be achieved with significant savings in operational costs than are available with conventional HEPA filters. Similarly, lower grade, deep V-pack or other forms of deep filter material could be safely electrically enhanced to produce higher efficiency filters having significantly lower pressure drops. The operating cost savings would be in terms of fan power required and the longevity of the filter, improvements that result in savings in terms of energy, downtime, labor and material costs related to filter replacement and maintenance. The consequential benefits in industrial applications (cf. Jaisinghani, "*Energy Efficient Cleanroom Design*", 2000) could be as high as 60% savings in energy consumption related to air moving. Currently, commercial buildings in the U.S. annually consume about 0.75 quads of energy

attributed to the cost of moving air. If other industrial applications are included, the electrical energy consumed by fans in heating, ventilating and air conditioning applications are probably about twice this number. Embodiments of this invention would provide a significant reduction in the overall industrial energy consumption required for air moving and heating, ventilating and air conditioning (*i.e.*, HVAC) costs, this provides significant reductions in greenhouse gases and other pollutants associated with energy production. The estimated annual U.S. potential for savings in atmospheric carbon is about 9.7154×10^6 metric tons of carbon.